VIIRS Surface Type Products

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Chengquan Huang and Rui Zhang, UMD Geography

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VIIRS Surface Type Product Team

Name	Organization	Major Task
Xiwu Zhan	NESDIS-STAR	Government Lead
Chengquan Huang	UMD Geography	Technical Lead
Rui Zhang	UMD Geography	Algorithms and Production Lead
Marina Tsidulko	STAR-AIT	Land Data Processing
Ivan Csiszar	NESDIS-STAR	VIIRS Land Team Lead
Lihang Zhou	NESDIS-STAR	STAR-JPSS Program Manager

Outline

- Why Surface Type?
- VIIRS Annual Surface Type 2017 Product
  - Compositing Algorithm Improvement
  - VIIRS AST2017 to be delivered
- Surface Type Change Product
  - Needs for Daily Surface Type Data
  - Change detection algorithm testing
- Summary and Path Forward

Why Surface Type

ST-EDR/AST Requirements from JPSS L1RD

Attribute	Objective
Geographic coverage	Global
Vertical Coverage	
Vertical Cell Size	N/A
Horizontal Cell Size	1 km at nadir
Mapping Uncertainty	1 km
Measurement Range	17 IGBP classes
Measurement Accuracy	70% correct

- Evergreen Needleleaf Forests
- Evergreen Broadleaf Forests
- Deciduous Needleleaf Forests
- Deciduous Broadleaf Forest
- Mixed Forests
- Closed Shrublands
- Open Shrublands
- Woody Savannas
- Savannas
- Grasslands
- Permanent Wetlands
- Croplands
- Urban and Built-up Lands
- Cropland/Natural Vegetation Mosaics
- Snow and Ice
- Barren
- Water Bodies

Why Surface Type

Surface Type Plays Important Roles in Many Climate Processes

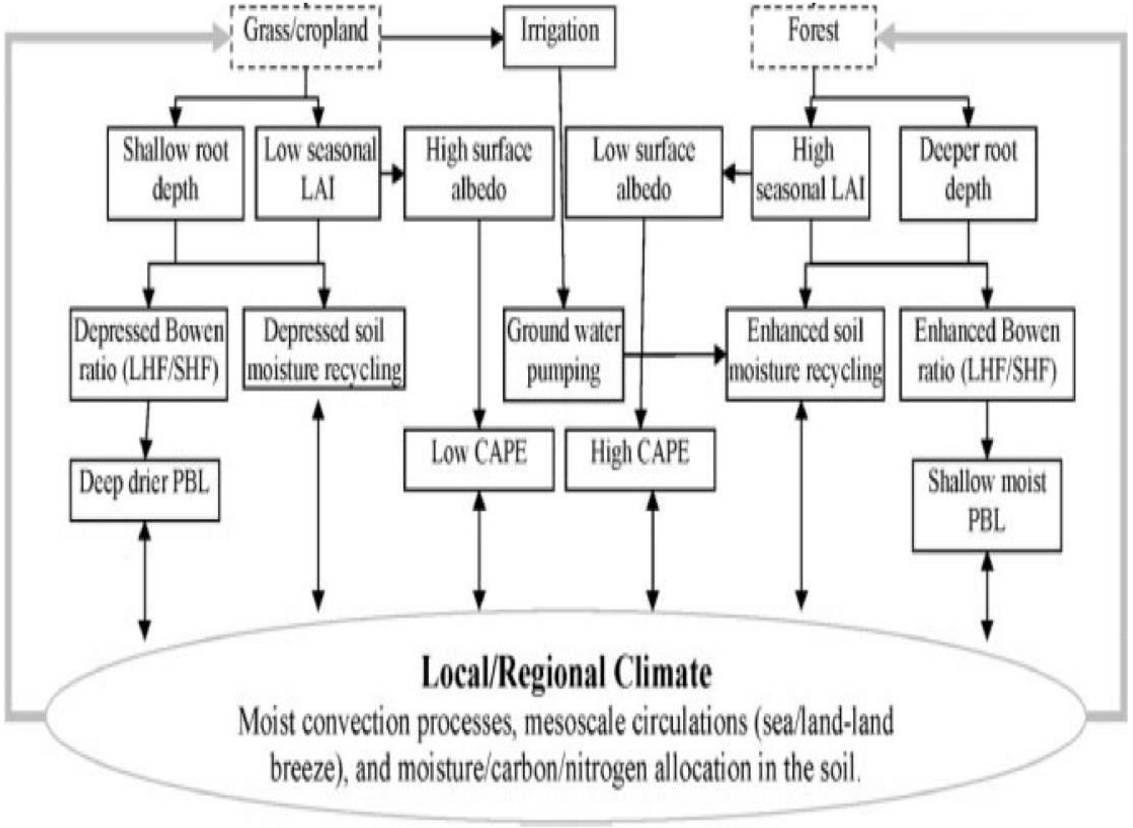
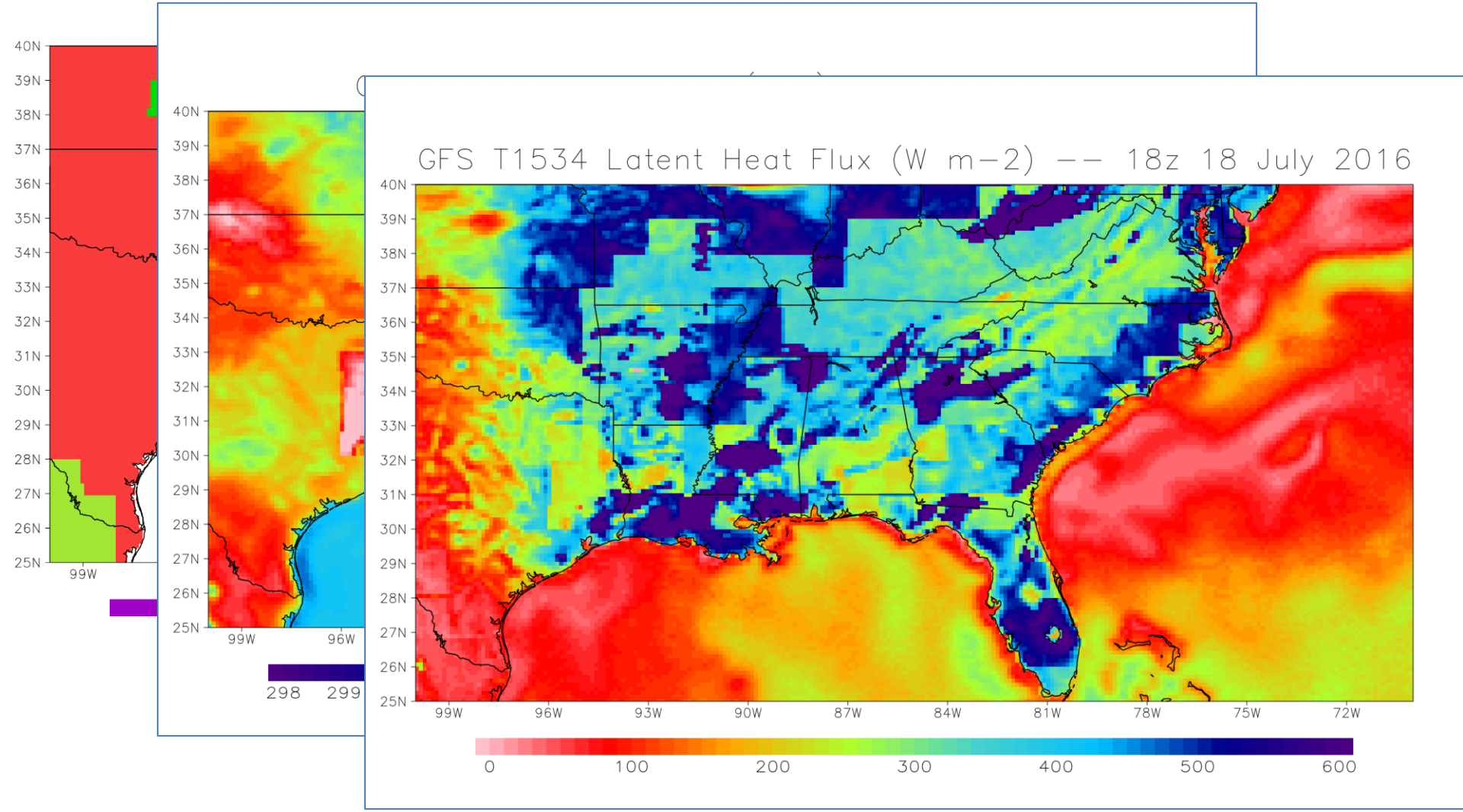


Figure 2. Conceptual model of the impacts of LCC on local and regional climate (Source: Pielke *et al.*, 2007).

Mahmood, R., Pielke, R.A., Hubbard, K.G., Niyogi, D., Dirmeyer, P.A., McAlpine, C., Carleton, A.M., Hale, R., Gameda, S., Beltrán-Przekurat, A., Baker, B., McNider, R., Legates, D.R., Shepherd, M., Du, J., Blanken, P.D., Frauenfeld, O.W., Nair, U.S., & Fall, S. (2014). Land cover changes and their biogeophysical effects on climate. *International Journal of Climatology, 34, 929-953.*

Why Surface Type

Surface Type Plays Important Roles in NWP models



Why Surface Type

- GLDAS is tested using either old AVHRR ST or newer MODIS/VIIRS QST IP
- Root-zone soil moisture estimates based on MODIS/VIIRS ST have better agreement with in situ measurements

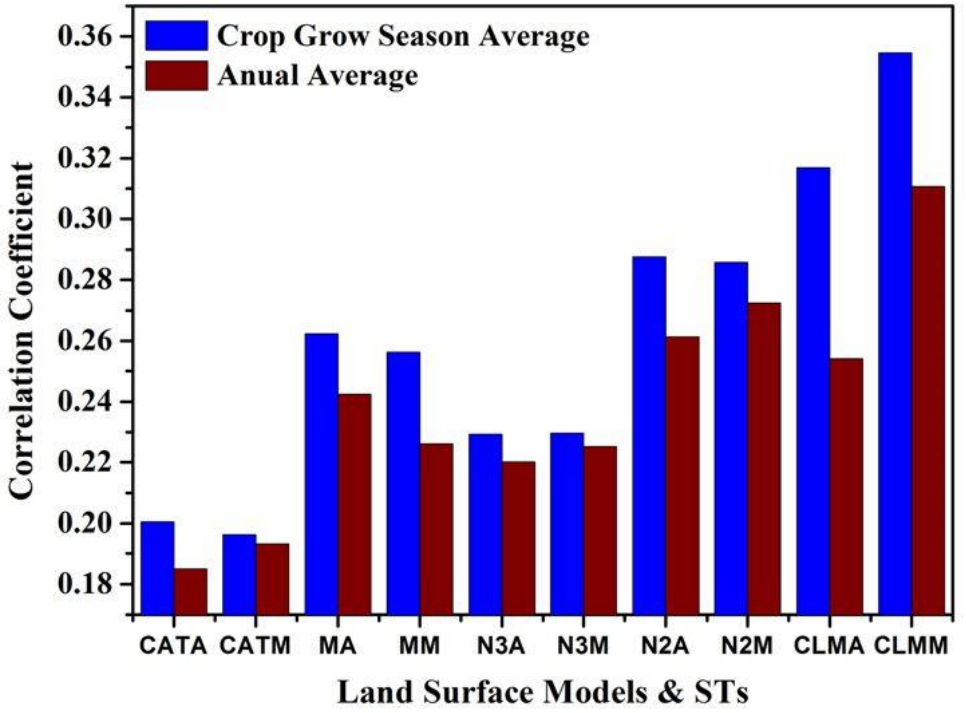
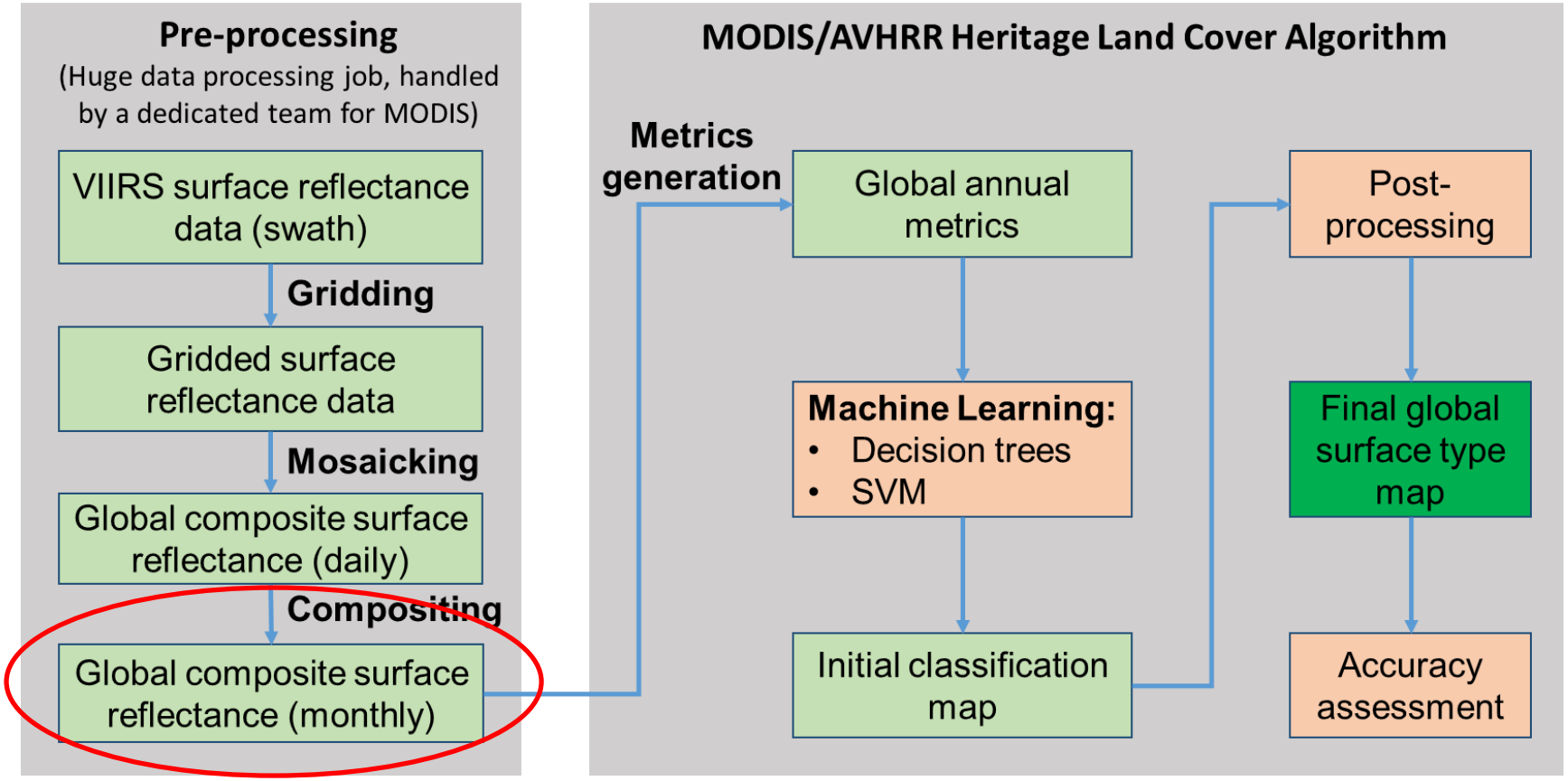


Fig. 1. The relationship between in-situ observational relative soil moisture of 108 stations and soil moisture simulated by land surface models with AVHRR and MODIS land cover over China mainland from January 2011 to December 2012. For each month, the sample size is 324, consisting of 108 stations data for every ten-day observation time interval. If correlation coefficients are more than o.16, 0.22 and 0.29, they are significant with credibility level 0.05, 0.01 and 0.001 separately. Crop grow season is from April to September in 2011 and 2012. The symbols of CATA, CATM, MA, MM, N3A, N2A, N2M CLMA and CLMM indicate Catchment, Mosaic, Noah3.2, Noah2.7.1 and CLM2.0 land surface models (LSM) implemented in LIS respectively. ST is surface type.

Jifu Yin, Youfei Zheng, Xiwu Zhan, Christopher R. Hain, Qingfei Zhai, Changchun Duan, Rongjun Wu, Jicheng Liu & Li Fang (2015) An assessment of impacts of landcover changes on root-zone soil moisture, *International Journal of Remote Sensing*, 36:24, 6116-6134, DOI: 10.1080/01431161.2015.1111539

VIIRS Annual Surface Type 2017

- Improve compositing algorithm
- Generate AST product with 2017 VIIRS Data



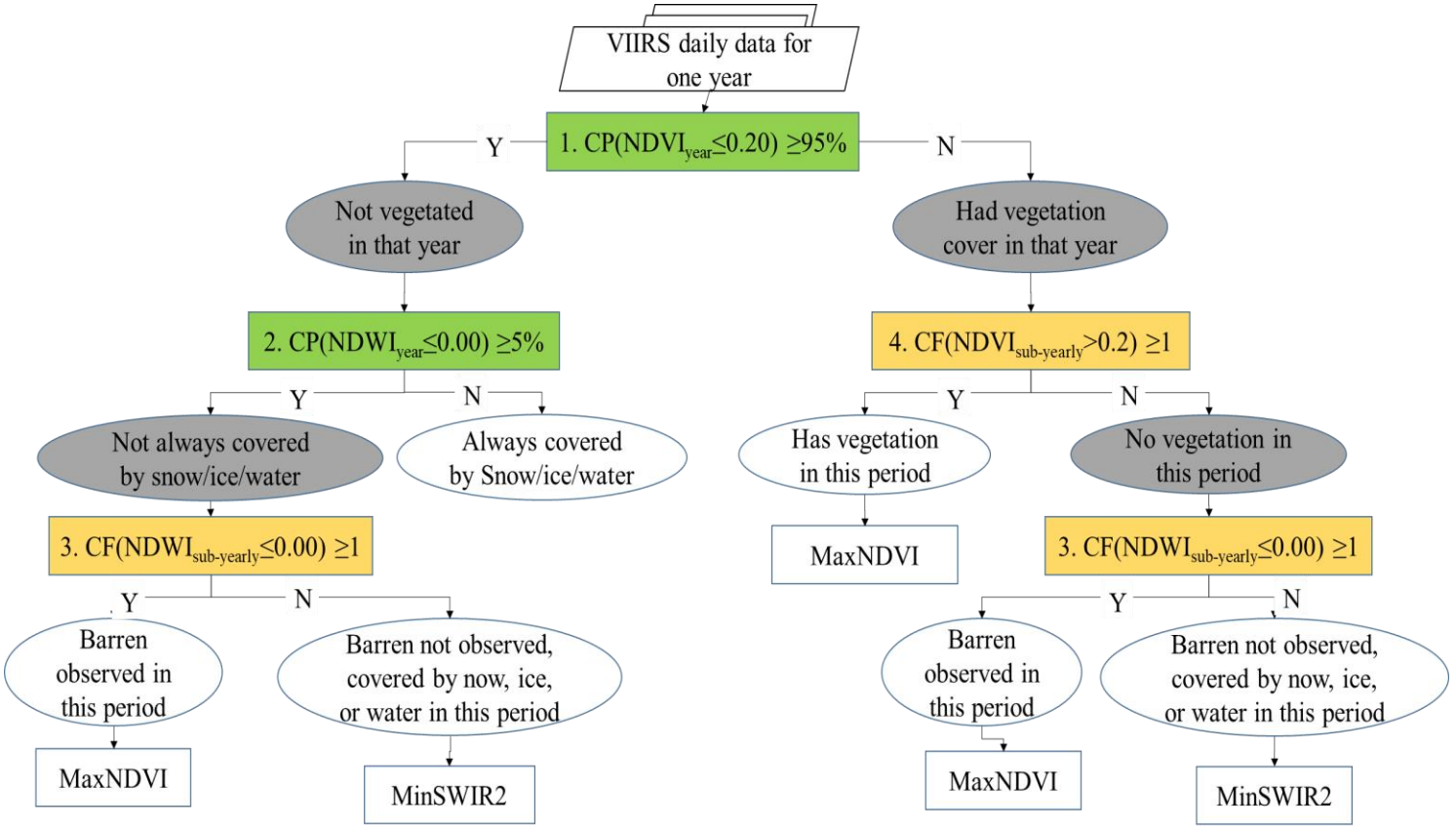
VIIRS Annual Surface Type 2017

A New Self-Adaptive Compositing (SA-Comp) Algorithm

- Previous compositing algorithms:
  - Limitations: Good at one aspect, bad for others
  - MODIS algorithm requires cloud mask/QA flags
- Automated surface cover condition determination
  - Vegetated
  - Water
  - Snow/ice
  - Other
- Different method for different surface conditions
- Major improvements over
  - Barren
  - Water
  - Snow/ice
- Published by ISPRS Journal of P&RS

VIIRS Annual Surface Type 2017

A New Self-Adaptive Compositing (SA-Comp) Algorithm

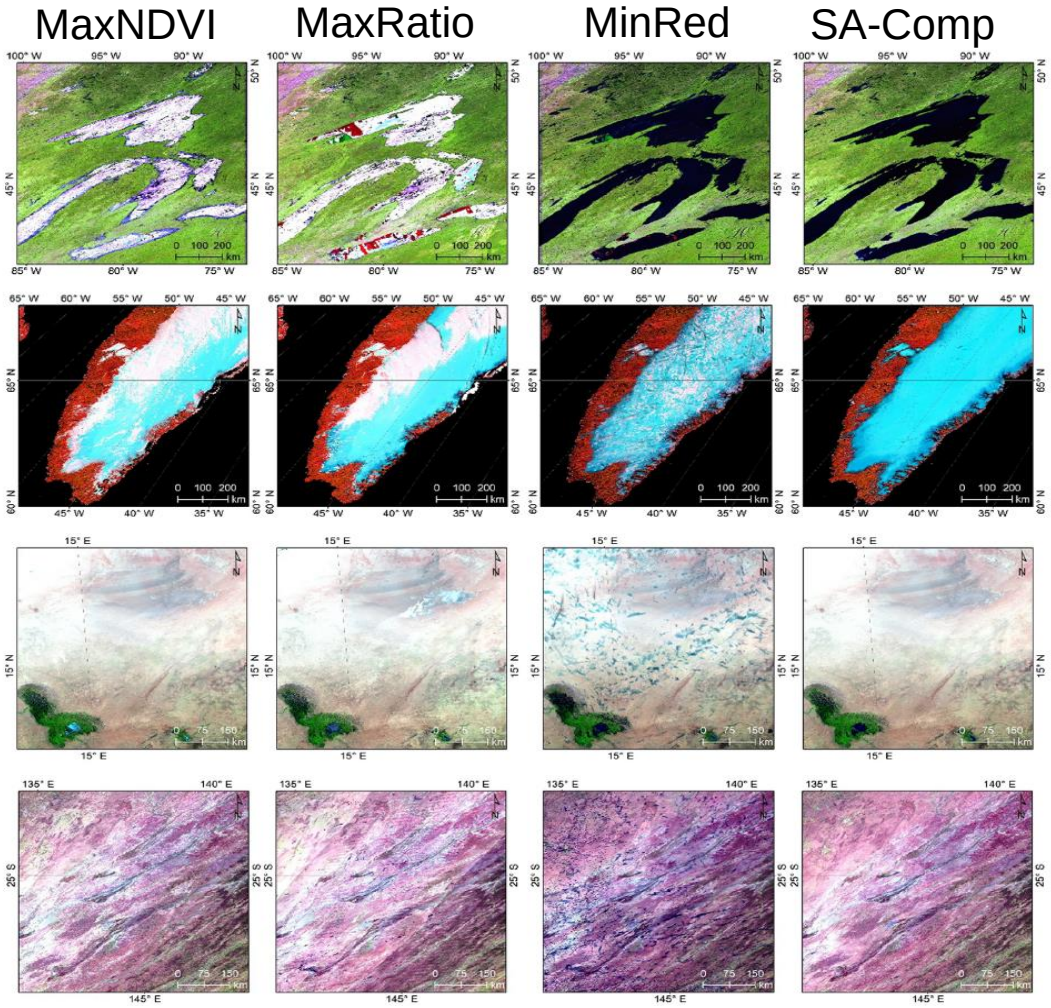


Bian, J., Li, A., Huang, C., Zhang, R., & Zhan, X. (2018). A self-adaptive approach for producing clear-sky composites from VIIRS surface reflectance datasets. *ISPRS Journal of Photogrammetry and Remote Sensing, 144, 189-201.*

VIIRS Annual Surface Type 2017

A New Self-Adaptive Compositing (SA-Comp) Algorithm

Better Than Single-Criterion Methods



VIIRS Annual Surface Type 2017

A New Self-Adaptive Compositing (SA-Comp) Algorithm

Better Than

MODIS

Heritage

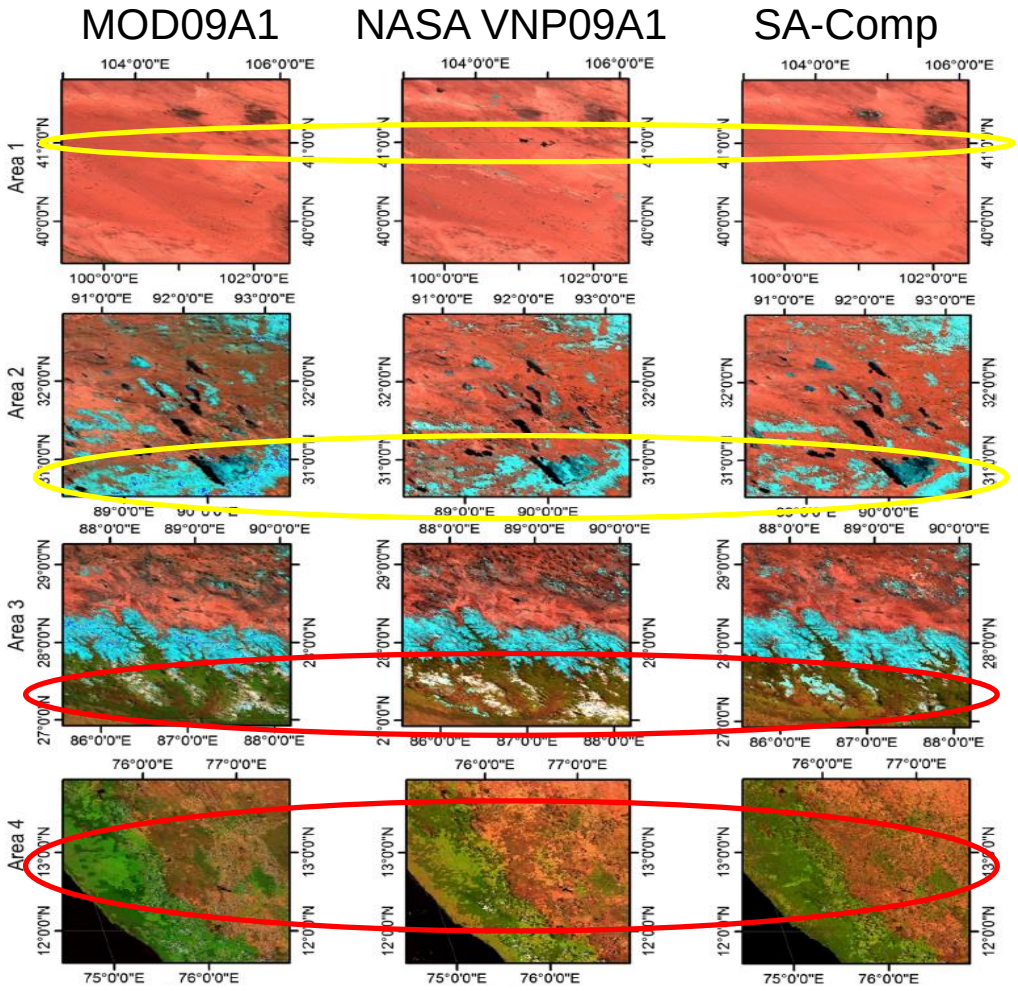
Methods

Less shadow

Non-snow selected when exist

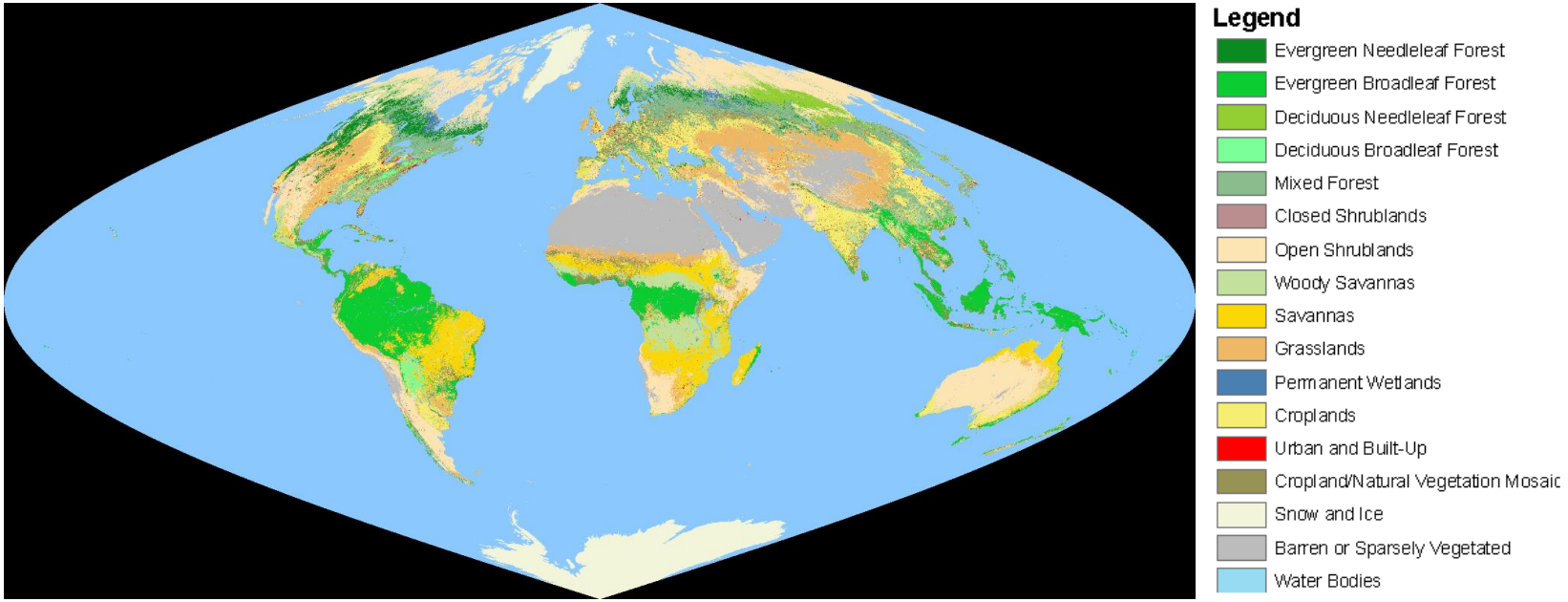
Less cloud

Smoother results over vegetated and non-vegetated areas



VIIRS Annual Surface Type 2017

- Generated using 2017 VIIRS data acquired between:
  - 1/1/2017 – 12/31/2017
- Available in two projections:
  - Sinusoidal
  - Lat/long
- FTP download:
  - ftp://vct.geog.umd.edu/ST/S-NPP_VIIRS_GST_IGBP_2017.zip
  - ftp://vct.geog.umd.edu/ST/S-NPP_VIIRS_GST_IGBP_2017_30arcsec.zip



VIIRS Annual Surface Type 2017

Validation of 2017 VIIRS AST Product

		Reference																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total (%)	User's accuracy (%)	Producer's accuracy (%)
Map	1	1.86	0	0.06	0.04	0.29	0	0.01	0.21	0.04	0.04	0	0	0	0.01	0	0	0.02	2.6	71.7±2.9	70.7±3.5
	2	0	8.52	0	0.09	0.12	0	0	0.42	0.09	0.03	0	0.05	0	0.06	0	0	0	9.39	90.7±1.2	93.1±1.1
	3	0.05	0	0.97	0	0.11	0	0.05	0.11	0	0	0.04	0	0	0	0	0	0	1.33	73.2±3.9	66.6±4.8
	4	0	0	0.01	0.77	0.04	0	0	0.09	0.03	0	0	0	0	0.01	0	0	0	0.94	81.7±3.0	34.4±3.1
	5	0.19	0.12	0.29	0.74	3.64	0.03	0	0.63	0.15	0.02	0.02	0	0.02	0.27	0	0	0.02	6.12	59.4±2.6	77.1±2.5
	6	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0.06	77.8±5.7	3.1±0.6
	7	0.21	0	0.05	0.07	0.17	0.6	11.78	0.52	0.41	1.48	0.21	0.41	0.02	0.17	0	0.55	0.02	16.67	70.7±1.7	84.8±1.7
	8	0.27	0.16	0.04	0.31	0.13	0.06	0.24	5.06	0.59	0.12	0.05	0.07	0.01	0.39	0	0	0.02	7.5	67.4±1.9	58.4±2.2
	9	0	0.21	0.03	0.05	0.05	0.43	0.32	0.85	4.63	0.21	0.03	0.21	0	0.56	0	0	0	7.59	61.1±2.9	67.8±2.7
	10	0.03	0	0.01	0.01	0.06	0.23	0.69	0.24	0.26	6.31	0	0.58	0.01	0.2	0	0.23	0	8.85	71.3±1.7	67.2±2.4
	11	0.01	0.03	0	0	0.01	0	0.07	0.04	0.05	0.01	0.54	0	0	0	0	0	0	0.77	69.6±6.2	60.1±7.3
	12	0.01	0.01	0	0.02	0.03	0.03	0.09	0.07	0.16	0.42	0.01	6.85	0.05	0.61	0	0	0.02	8.38	81.8±1.2	79.2±1.7
	13	0	0	0	0	0	0	0.01	0.03	0	0.01	0	0.07	0.52	0.04	0	0	0	0.69	75.0±3.6	80.6±5.4
	14	0	0.1	0.02	0.12	0.06	0.01	0.07	0.4	0.4	0.18	0	0.37	0.01	2.77	0	0.01	0	4.51	61.4±2.1	54.0±2.7
	15	0	0	0	0	0	0	0.17	0	0	0.17	0	0	0	0	10.06	0	0	10.41	96.7±2.3	100.0±0.0
	16	0	0	0	0	0	0	0.4	0	0	0.35	0	0.04	0	0.04	0	12.21	0	13.06	93.6±1.4	94.0±1.0
	17	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	1.11	1.13	98.3±1.7	91.4±3.1
	Total	2.63	9.16	1.46	2.24	4.72	1.43	13.89	8.66	6.83	9.39	0.89	8.65	0.64	5.13	10.06	13	1.21	100		

Overall accuracy is 77.6 ± 0.6%.

VIIRS Surface Type Change Product

Surface Type Highly Dynamic

- Conversions
  - Deforestation
  - Urban sprawl
  - Desertification
  - Revegetation
  - Other type conversions
- Short term changes
  - Vegetation phenology
  - Seasonal snow cover
  - Flooding/short term inundation
  - Wildfire burning

VIIRS Surface Type Change Product

Needs for Surface Type Change/Daily Surface Type Product

- Surface Type Change Can Result in changes in Key Climate Variables

  Li, F., Lawrence, D.M., & Bond-Lamberty, B. (2017). Impact of fire on global land surface air temperature and energy budget for the 20th century due to changes within ecosystems. *Environmental Research Letters, 12, 044014.*

- ET Varies with Inundation Level Changes

  Zhao, X., & Liu, Y. (2016). Evapotranspiration Partitioning and Response to Abnormally Low Water Levels in a Floodplain Wetland in China. *Advances in Meteorology, 2016, 11.*

- Local Surface Temperature and Precipitation Change from Deforestation

  Winckler, J., Reick, C.H., & Pongratz, J. (2017). Robust Identification of Local Biogeophysical Effects of Land-Cover Change in a Global Climate Model. *Journal of Climate, 30, 1159-1176.*

- Consistency check of land surface status (e.g. albedo, LST, GVF, fires, etc) requires near real time surface type data

VIIRS Surface Type Change Product

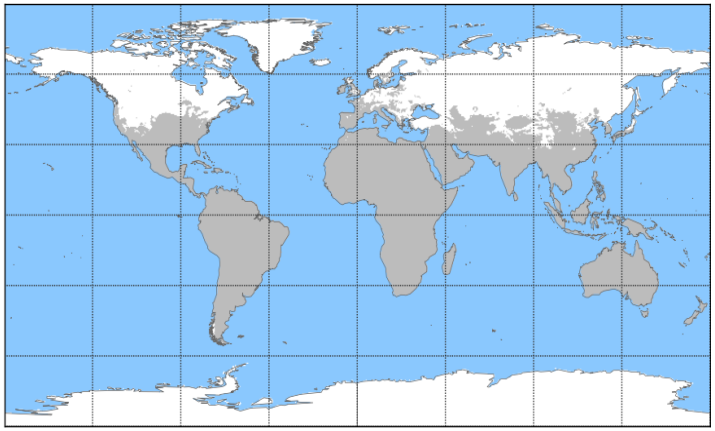
Feasibilities of Mapping Surface Type Change Using VIIRS

- Longer term surface type conversions should have been captured by AST
- Shorter term changes need to be detected or brought in, e.g.
  - Snow -> seasonal snow cover change
  - Flooding -> short term inundation
  - Fire/burned area -> fire driven changes
- Need to bring all these together in a single product suite – daily surface type product for users convenience

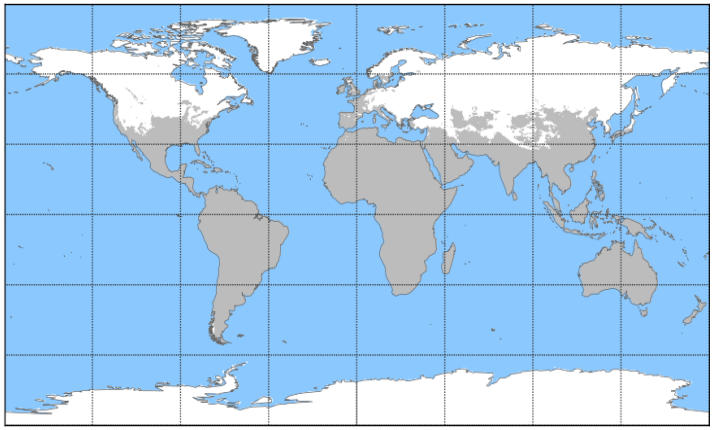
VIIRS Surface Type Change Product

Daily Snow Coverage Has Already Been Available from VIIRS Snow Product Team

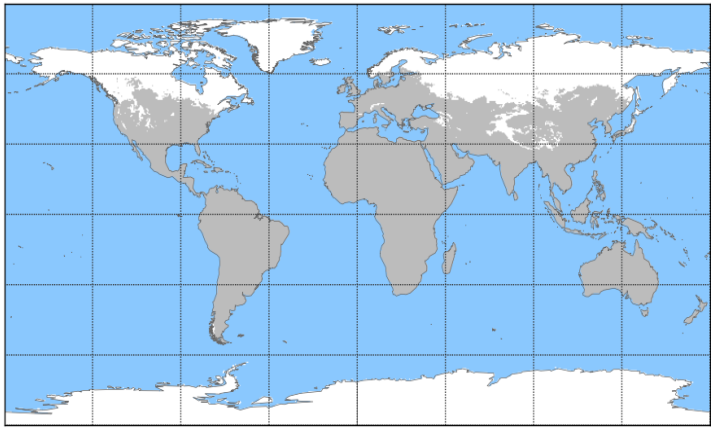
1 Jan 2017



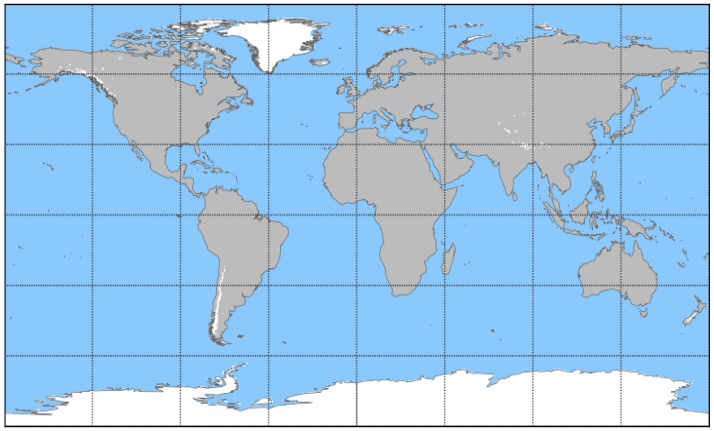
1 Feb 2017



15 Apr 2017



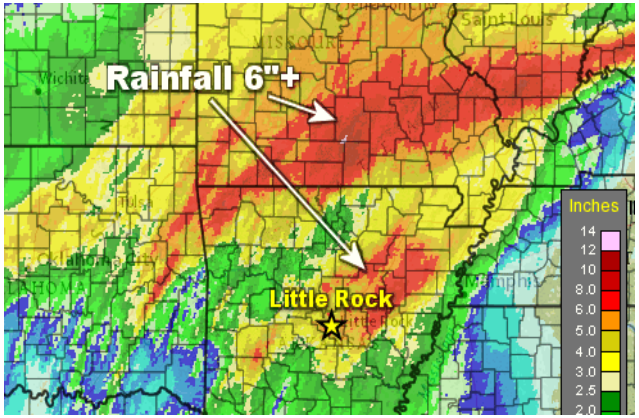
1 Aug 2017



VIIRS Surface Type Change Product

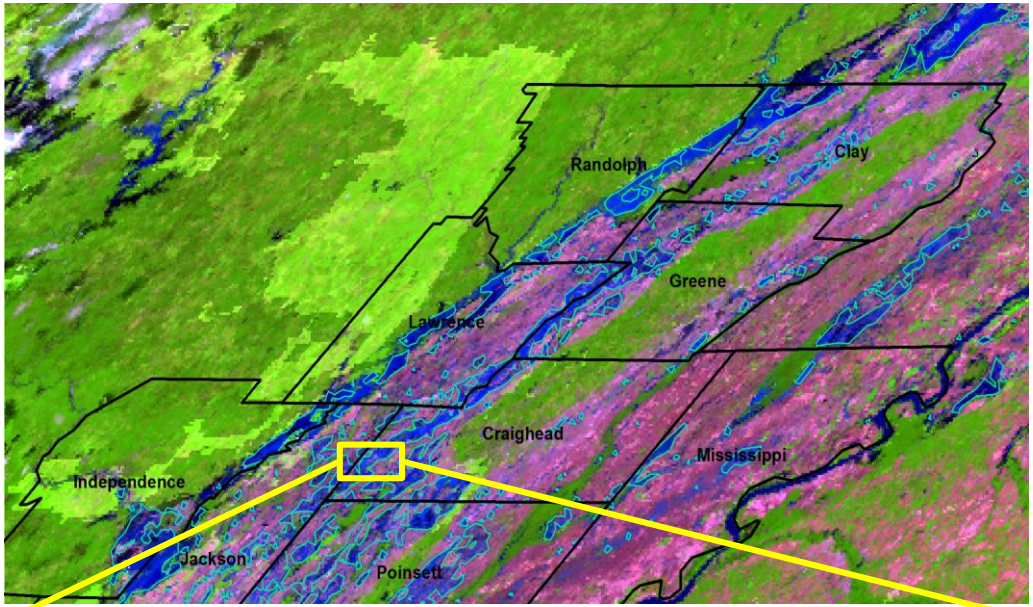
Flood Can Be Mapped When Cloud Free Observations Are Available

1. Heavy Rains on April 29-30, 2017



2. Levee Breach on May 3, 2017

3. Widespread flooding in Arkansas observed by SNPP satellite

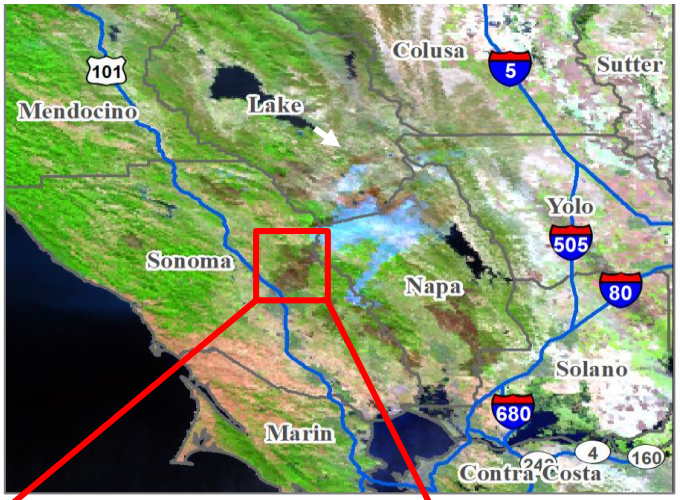


4. Detailed verification by Landsat

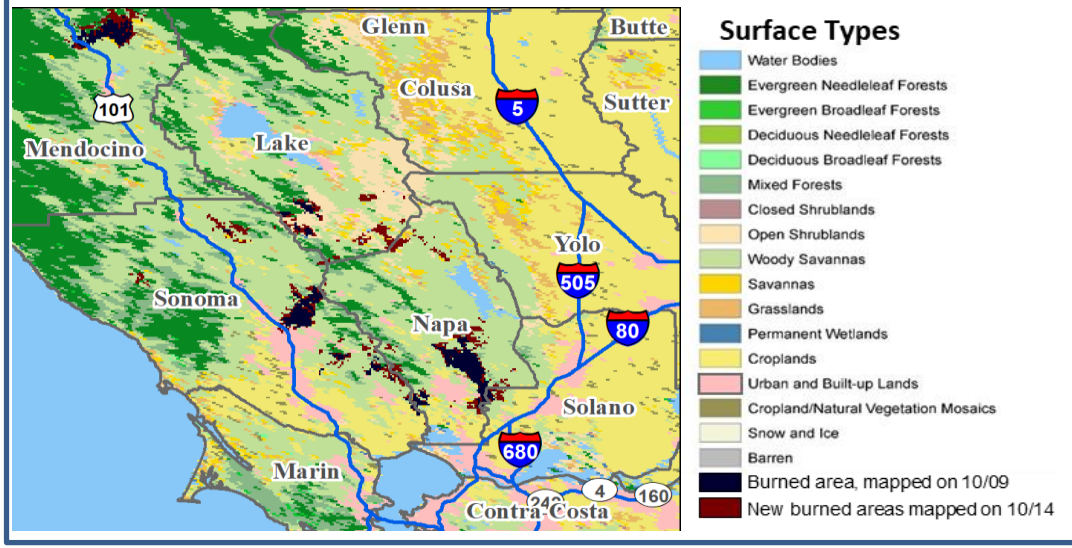
VIIRS Surface Type Change Product

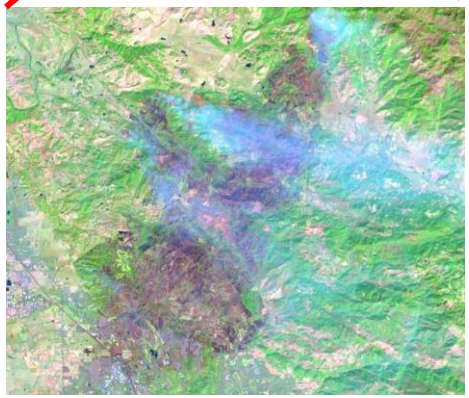
Prototype Mapping of Burned Area Using VIIRS

VIIRS image showing multiple fires in CA, October 14, 2017



Surface type map showing new burned areas, Oct. 14





Landsat image showing fire and burned area, Oct. 11, 2017 (left)

High resolution images showing smokes of fire (right)

Summary & Path Forward

- *Surface type is an important **input parameter** for many **NWP** and other land surface models*
- *A **self-adaptive compositing algorithm** has been used for compositing VIIRS 2017 surface reflectance and surface type classification metrics*
- *The new **VIIRS Annual Surface Type 2017** product has been generated and validated, will be delivered to NCEP users and distributed to other users through STAR-JPSS website*
- *A global gridded **daily surface type product** is needed to provide dynamic daily surface type information for users*
- *Team starts to work on VIIRS Annual Surface Type 2018 from both S-NPP and NOAA-20 and will continue to explore approaches/feasibilities toward the Daily Surface Type product*